5250-3, Vol. II

Photovoltaics Program

Technology Development and Applications
Lead Center

Photovoltaic System Criteria Documents

Volume II: Quality Assurance Criteria for Photovoltaic Applications

Prepared for

U.S. Department of Energy

Through an agreement with
National Aeronautics and Space Administration

by

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

CONTENTS

SECTION I

INTRODUCTION

A. SCOPE

This publication describes quality assurance criteria for manufacturers and installers of solar photovoltaic tests and applications. It outlines quality-oriented activities to be pursued by the contractor/subcontractor to assure the physical and operational quality of equipment produced is included. In the broad sense it provides guidelines for establishing a QA organization if none exists. Mainly, it provides criteria to be considered in any PV quality assurance plan selected as appropriate by the responsible Field Center.

The criteria are to be considered by the contractor/subcontractor in support of designing, developing, fabricating, assembling, inspecting, testing, handling, delivery and field site operation of all photovoltaic tests and applications. Note: the term "contractor" refers to the prime system installer as chosen through award by the Field Center.

B. PURPOSE

The purpose of this document is to establish a framework for a systematic approach to ensure that photovoltaic tests and applications are constructed in a timely and cost-effective manner. It highlights preventive as well as verification activities and functions. It requires that adequate and proper design definition be made; that procured items be controlled; that fabrication and assembly activities be defined and controlled; and it provides verification functions and activities to insure that consistently acceptable hardware is produced.

C. QUALITY PROGRAM

The contractor should be responsible for establishing and operating a cost-effective quality program in response to these criteria, tailored to the requirements of the contract, including applicable regulations, codes, standards and specifications. The quality program should be so designed and implemented as to incorporate existing effective procedures and practices which satisfy these guidelines (see Figure 1-1). The contractor is not expected to create new procedures and practices for each element of the guideline, but he is expected to revise existing procedures and practices, if needed, to meet these guidelines. Good quality control activities are summarized in Appendix B.

1. Relation to Other Requirements

The quality program criteria set forth in this publication should be satisfied in addition to all detail requirements contained in the statement of work or in other parts of the contract. Overlapping and interfacing contractual requirements such as reliability, safety and test must not result in duplication of contractor efforts. The quality program should effectively complement and support functions set forth in contract requirements. To the greatest extent possible, the contractor's existing quality and inspection programs should be used to minimize changes to an acceptable operating quality system.

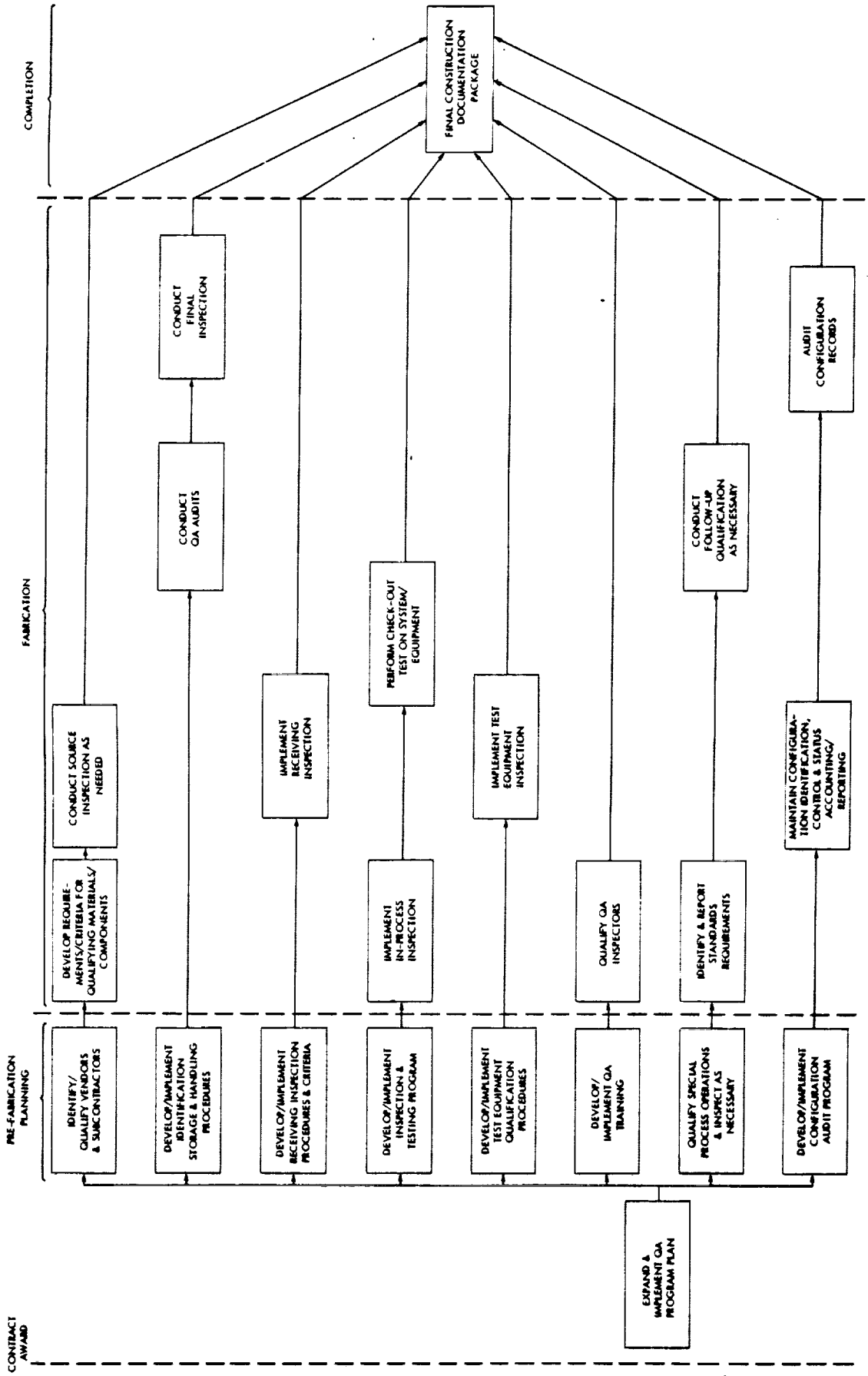

Figure 1-1. Sample QA Phase Activities

2. Quality Organization/Responsibilities

No single organizational pattern will be mandatory to satisfy these criteria. Personnel performing quality functions will have sufficiently well-defined responsibility and the organizational freedom required to recognize and assess quality problems and to initiate and provide solutions.

SECTION II

APPLICABLE DOCUMENTS

Military: MIL-STD-810C, "Environmental Test Methods," March 10, 1975

National Aeronautics & Space Administration: NASA-TM73702, "Terrestrial Photovoltaic Measurement Procedures,", June 1977, Lewis Research Center, Cleveland, OH.

Jet Propulsion Laboratory: JPL/LSA Project

A. JPL Document 5101-21, Rev. B, "Acceptance/Rejection Criteria for JPL/LSA Modules,", November 3, 1978.

B. JPL Document 5101-26, Rev. A, "Solar Cell Module Problem/Failure Reporting Procedure," January 12, 1979.

C JPL Document 5101-65, "Photovoltaic Module Design, Qualification and Testing Specification," March 24, 1978.

D. JPL Document 5101-16, Rev. A., "Block IV Solar Cell Module Design and Test Specification for Intermediate Load Center Applications," November 1, 1978.

E. Quality Assurance Workmanship Standards (QAWS)

Jet Propulsion Laboratory: JPL/Photovoltaics TDA Lead Center Criteria Documents

5250-3, Vol. I Guidelines for Evaluating the Development, Management and Operations Planning of PV T&A

5250-3, Vol. II (this document)

5250-3, Vol. III Environmental Issues and Evaluation Criteria for PV T&A

5250-3, Vol. IV (Design) Review Criteria for PV T&A

5250-3, Vol V Safety Criteria for PV T&A

5250-3, Vol. VI Guidelines for Conducting PV Site Audits

5250-3, Vol. VII PV Applications Assessment Criteria

Other Codes, Specifications or Standards

SERI/MR-61-270: Interim Implementation Structure for Development of Performance Criteria and Standards for Photovoltaic Systems.

SECTION III

REQUIREMENTS

A. APPLICABILITY

This document is applicable to the extent specified in the contractual instrument. It should also apply to subcontractors to which the provisions herein are pertinent, as determined by the procuring agency. It is the responsibility of the Field Center (government procuring agency) to determine which of these criteria are to be applied in total or in part to individual projects on a level appropriate to the scope of the project, and consistent with goals and resources

B. QUALITY PROGRAM PLAN/PRELIMINARY

The Field Center should have the contractor prepare, maintain, and implement a Quality Program Plan, which describes how the contractor will ensure compliance with cited quality requirements. The Quality Program Plan must be submitted as required by the Request for Proposal or contract. The Plan format must be readily identified with each cited requirement. The Plan should cover all quality program activities and be consistent with the intent of this publication.

C. FLOW CHART

As a part of the preliminary plan, the contractor should submit copies of a preliminary "block type" flow chart. The flow chart should specify numerical sequences of operations and inspections that will be performed by the contractor to provide assurance that all supplies or equipment meet contractual requirements (Figure 3-1).

The preliminary plan and flow chart should include, but not be limited to, the following functions as applicable to the size of the project:

- source inspection
- receiving inspection
- in-process inspection
- testing
- final inspection
- shipping inspection
- field installation and checkout
- operations auditing

} or appropriate warranties

D. FINAL QUALITY PLAN/FLOW CHART

The content and format of the final Quality Assurance Plan must conform to the approved preliminary plan and flow chart. Written approval for the final Quality Assurance Plan must be received by the contractor prior to implementation thereof, and within 10 days after award of the contract.

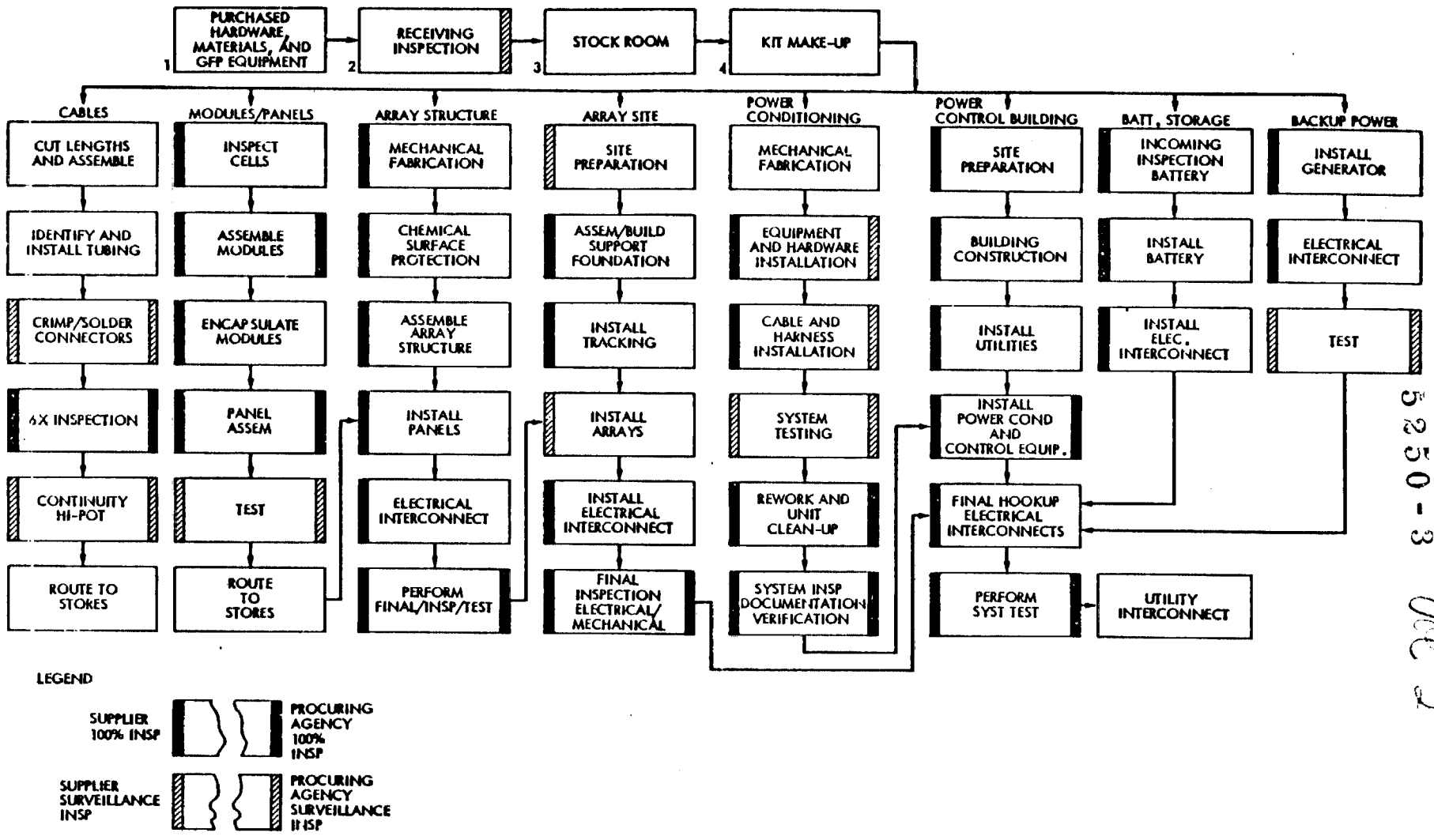

Figure 3-1. Sample Operation and Inspection Flow Chart

The QA Plan must show which performance attributes are to be measured, inspected and/or verified, by which methods and to which specification source. PV and PV/T attributes to be considered are: function, electrical, mechanical, structural, fluids, optical, interface, compatability, durability, safety, temperature and maintainability. To be effective, critical inspection points must be determined. Where applicable, information gathered from the Technology Development and System Engineering and Standards subprograms should be used. Consideration must be given as to when/where the contractor's QA people must inspect or where subcontract/supplier in-house inspection will suffice. This determination will be made by the responsible Lead Center

E. PROCUREMENT CONTROLS

1. Contractor Responsibility

The contractor should be responsible for the adequacy and quality of all purchased material. As part of the procurement requirements, the contractor should pass on to his suppliers all contractual and specification requirements levied on him as appropriate to the hardware being procured.

The PV & PV/T applications will range in size, complexity and cost. Initial System Evaluation Experiments (ISEE) are pre-prototypes intended to investigate the feasibility of photovoltaics in chosen applications. System Readiness Experiments (SRE) are prototypes that provide evidence that the components and subsystems are technology ready. Both ISEE or SRE will be used in residential, intermediate load center and central station applications. The following suggestions are offered for level of contractor procurement control:

Residential (ISEE) - Near-total control: at least to component level (inverter, generator, individual PV modules, building material, all shelf items).

Residential (SRE) - Could use less control than for ISEE. (PV module groups; material groupings for structure, electrical, plumbing, packaged assemblies/shelf items).

Remote/Stand Alone (ISEE & SRE) - At least to module level. Defined as smallest environmentally protected assembly.

Intermediate Load Center - (ISEE & SRE) To subsystem level as defined in PV System Glossary (array field, PC&C, storage, backup, etc.).

2. Receiving Inspection/Source Inspection

Articles and materials should be inspected upon receipt. When it is not practical or feasible to determine quality conformance upon receipt, the contractor should assign Quality Assurance personnel to perform inspections at supplier facilities. When contractor source inspection activity is required at a supplier's facility, the procurement document should so indicate.

3. Changes

The supplier should be required to notify the contractor of any proposed changes in design, fabrication methods or processes approved by the contractor, including changes which may affect the quality or intended use of the item, and obtain written approval of the change. Changed articles should be identified differently from previous articles. When a proprietary item is procured by the contractor, the supplier should be required to notify the contractor of changes.

F. QUALITY SUPPORT TO DESIGN REVIEW

Quality Assurance personnel shall participate in design reviews to ensure that designs permit and facilitate producibility, repeatability and inspectability and that related quality considerations are obtained. All subsystems of the photovoltaic power system as shown in Figure 3-2 shall be reviewed to the least replaceable unit level, including mounts and electrical and mechanical interconnects.

G. DOCUMENTATION/CHANGE CONTROL

1. Technical Documents

The contractor must establish, document and ensure compliance with design control requirements and quality criteria during all phases of contract work. Contractor technical documents such as specifications, procedures, drawings, fabrication and planning documents, and process sheets must be developed and should include, as applicable, the following information:

Characteristics and design criteria necessary for procurement, fabrication (including assembly) and inspection and test operations.

Characteristic tolerance or limits.

Identification in accordance with Section IV, paragraphs 2 and 3.

2. Document Review

Contractor Quality Assurance personnel should conduct early reviews of technical documents, and changes thereto. Reviews must ensure that all necessary information has been included and that requirements are clear and unambiguous. The reviews shall be documented, deficiencies in the documents reported to responsible personnel, and action taken to ensure correction of the deficiencies prior to document release. These reviews must be used in timely quality planning for subsequent procurement, fabrication, inspection and test activities.

3. Change Control

The contractor must ensure control of all documents and changes thereto affecting the quality program. Documents should be distributed to the

12

AN INSTALLED AGGREGATE OF SOLAR ARRAYS AND OTHER SUBSYSTEMS TRANSMITTING POWER TO A GIVEN APPLICATION. A SYSTEM WILL GENERALLY INCLUDE THE FOLLOWING SUBSYSTEMS:

A) ARRAY FIELD

B) POWER CONDITIONING AND CONTROL

C) STORAGE (IF REQUIRED)

D) BACKUP (IF REQUIRED)

E) THERMAL (IF REQUIRED), NOTING THAT PORTIONS OF A THERMAL SUBSYSTEM MAY BE INCLUDED IN THE FABRICATION OF THE ARRAY)

F) LAND, SECURITY SYSTEM AND BUILDINGS

G) ON-SITE CONDUIT/WIRING

H) INSTRUMENTATION

I) MAINTENANCE AND REPAIR EQUIPMENT

Figure 3-2. Photovoltaic Power System and Subsystems

operating areas and obsolete documents removed. The change control system shall be documented. The control system must provide for initiation of document change requests. Changes which involve interface relations or which affect articles not under design control of the contractor must be coordinated with the affected parties. The contractor should effectively integrate these requirements with other document control requirements of the contract.

H. PROCESS CONTROLS

Controls, including written procedures, must be established over processes for which the uniform quality of articles or materials cannot be assured solely by inspections or tests. These processes include, for example, plating, anodizing, bonding, painting, soldering, welding, and for non-destructive inspection operations such as radiography, ultrasonics, magnetic particle and liquid penetrant inspection. When approval or certification of processes, personnel, equipment, drawings, specifications or procedures is required by contract, such approvals or certifications of processes must be obtained prior to processing articles and materials. Special or hazardous processes shall be identified with applicable regulations, codes, standards or specifications. Records shall be maintained of approvals and certifications or processes, personnel, equipment and procedures, and results of inspections associated with processes. These records shall be maintained to evidence continuous control over the processes involved.

I. INSPECTION AND TEST CONTROLS

Procured and fabricated articles and materials should be inspected and tested to ensure conformance to contract requirements including applicable drawings, specifications and changes thereto. These inspections should occur during receiving, processing, fabrication, assembly, and shipping phases.

Written inspection and test procedures must be prepared, supplementing contract requirements, to clarify details of the inspection and measuring equipment required, the detailed operations to be performed, the criteria for determining quality conformance or rejection of articles and materials and the results to be documented.

J. INSPECTION AND TEST RECORDS

Records of all inspection and tests performed should be maintained. The records must provide evidence that the required inspections and tests for individual articles and materials have been performed, including article or material identification, the inspection or test involved, the number of conforming articles or materials, and the nature of the nonconformances. When required, actual inspection and test results shall be included.

K. INSPECTION STATUS CONTROLS

Controls should be maintained for continuously indicating the inspection status of articles and materials by using identifications distinctly different from government inspection identification. This can be accomplished by means stamps, seals, or decals on individual articles and materials; or tags, routing cards, move tickets or other normal control devices attached to the articles, materials or their containers. Applications of stamps should not damage the articles or materials, or compromise their quality in any way. Stamping methods and materials shall be compatible with the articles and materials involved. Inspection status controls should also provide traceability to the individual(s) who perform the inspection.

L. FAILURE REPORTING/CORRECTIVE ACTION

A failure reporting systems shall be utilized to cover all malfunctions, deficiencies, and failures detected by the contractor and subcontractor's inspection and test operations. This system shall provide information necessary for corrective action to prevent recurrence. In addition, a copy shall be completed and forwarded to all parties as indicated in the contractual instrument (see Figure 3-3).

M. METROLOGY CONTROLS

A documented metrology system should be established and utilized to control measurement processes in order to provide objective evidence of quality conformance. Measurement standards and equipment must be selected and controlled to the degree necessary to meet contract requirements. Measurement processes must be performed in accordance with established written procedures.

N. CALIBRATION CONTROLS

1. Facilities

The contractor can use his own facilities or use the services of an outside facility for the calibration of measurement standards and equipment.

14

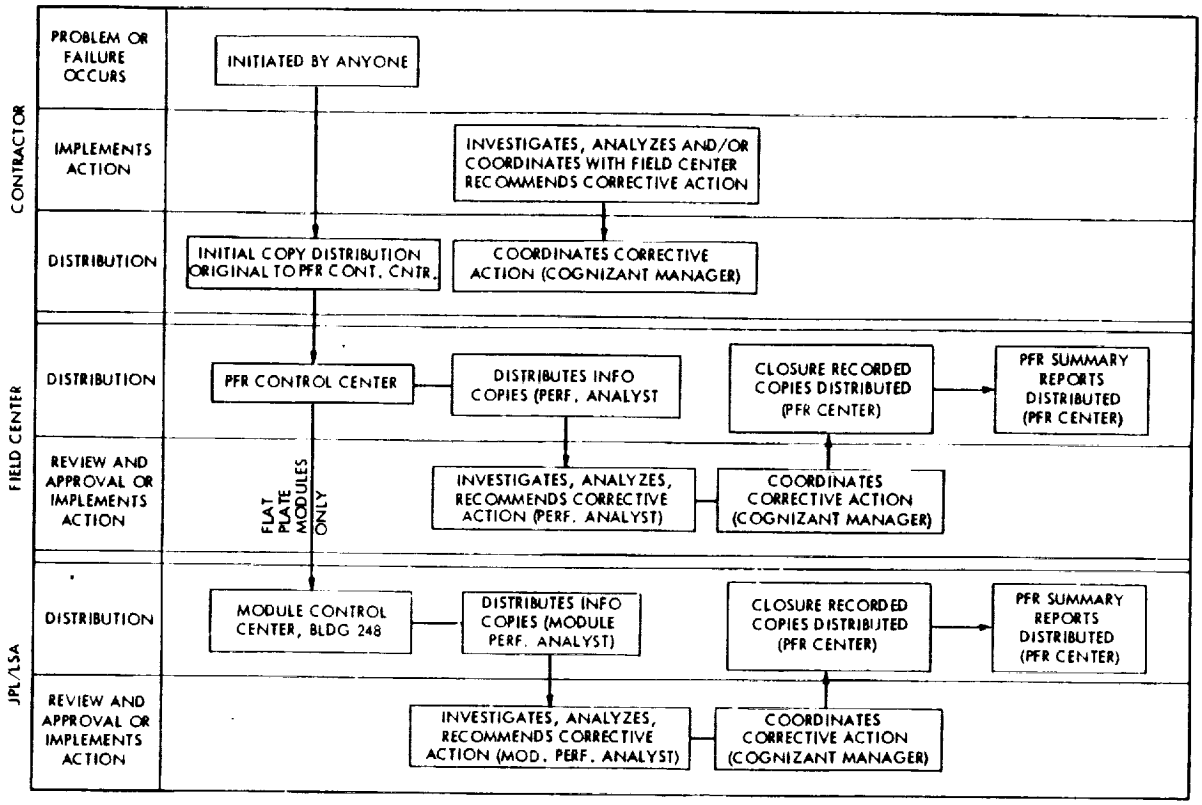

Figure 3-3. Sample PFR Flow Diagram.

2. Environments

Environmental characteristics (e.g., temperature, humidity, vibration, cleanliness) must be compatible with the accuracy requirements of the article of material and the measurement processes.

3. Traceability

All measurement standards shall be traceable to standards maintained by the National Bureau of Standards or their value(s) shall be derived from a controlled measurement process utilizing a fundamental constant of nature (Ref. IPC Document: SERI/MR-61-270).

4. Handling, Storage and Transportation

All measurement standards and equipment shall be handled, stored and transported in a manner which shall not adversely affect quality or result in hazardous conditions.

5. Identification and Labeling

All measurement standards and equipment shall be uniquely identified and labeled, tagged or coded to indicate calibration status and due date of next calibration. In the event of limited calibration, the limits for accuracy and range shall be indicated.

6. Recall System

All standards and equipment used in measurement processes shall be recalled and recalibrated at established intervals. Standards and equipment not recalibrated before the recall due date shall be removed from service or otherwise restricted from use.

O. WORKMANSHIP STANDARDS

Workmanship should be in accordance with the following requirements or as specified in the contractual instrument. The contractor's workmanship standards, after approval by the procuring agency, may be utilized. One copy of the contractor's workmanship standard shall be supplied with the proposal.

In the event the bidder/contractor does not have acceptable workmanship standards, JPL Quality Assurance Workmanship Standards (QAWS) 100.0-3000.00, where applicable, may be used as a guide (Appendix A). Copies of these documents may be obtained by requesting them from Lead Center Test & Applications. It should be noted that the Field Center retains responsibility for workmanship provided by the contractor.

SECTION IV

QUALITY ASSURANCE PROVISIONS

A. CONTRACTOR RESPONSIBILITY FOR INSPECTION

Unless otherwise specified in the contractual instrument, the contractor is responsible for the performance of all inspection requirements specified herein during all phases of the program. Properly expressed warranties might preclude need for records and inspection indications.

1. Quality Records

The contractor shall maintain records of inspection and test performance throughout the entire fabrication and acceptance process which shall be available to the procuring agency for review upon request. The records shall include the actual inspection and test data for the specific functions. These records shall be maintained for the period of time specified in the contract. If such period of time is not specified in the contract, these records shall be maintained for one year after completion of the contract.

2. Inspection Indications

The contractor shall establish and maintain an inspection stamp procedure and documentation to clearly identify equipment that has been subjected to receiving inspection, first article inspection, in-process inspection, final subassembly, functional tests, or end item final inspection. Inspection indications shall be physically placed on the equipment and inspection and test data sheets. The inspection stamp shall also clearly identify the individual assigned. Nonconforming parts of equipment shall be segregated and identified with a red tag and documentation detailing the nonconformance.

B. SUPPLIER SELECTION

1. Procurement Participation

Contractor Quality Assurance personnel shall participate in the selection of procurement sources for the following:

a. High-value or safety related hardware

b. Hardware produced by special tooling, automated machines or by special fabrication processes; and

c. Hardware fabricated to contractor or procuring agency designs.

2. Pre-Award Surveys (Barring vendor's claims of proprietary information).

A pre-award survey of the suppliers facility and quality system should be conducted to determine if he is capable of satisfying procurement quality requirements.

C. CONTRACTOR SOURCE INSPECTION

When contractor Quality Assurance source inspection activity is required at subcontractor's (supplier's), the procurement document should so indicate.

Source inspection and/or inspection system evaluation should be accomplished by contractor's representatives at the supplier's plant when:

a. Characteristics and features identified as essential to safety, reliability or operation are not inspectable or testable after receipt, or are not economical to inspect or test after receipt.

b. The supplier's quality program or inspection system is suspected of causing poor product quality, or when the suplier provides complex, high-value or critical hardware.

Inspection at source should be at the highest level of assembly at which the essential characteristics or features are accessible for inspection. The purchasing activity should inspect additional characteristics and features and increase the depth and frequency of inspection if the supplier's product quality history is less than required.

D. PROCURING AGENCY SOURCE INSPECTION

The Field Center or its designated representative should reserve the right to perform source inspection at the contractor's or his supplier's facility at any time and during any phase of the contract to assure that contractual requirements are being met.

These inspections should not in any way replace or relieve the contractor of his responsibilities for ensuring the quality of the product.

When mandatory procuring agency source inspection is required by contractual requirements, the procuring agency or its designated representative should be notified 48 hours in advance of the time articles or materials are ready for inspection or test.

E. MATERIAL CONTROL

The contractor is responsible for the adequacy of all purchased material. Controls and procedures should be utilized to ensure that only conforming articles and materials are released and used.

1. Handling and Storage

Methods and facilities must be established for controlling the identification, handling and storage of raw materials or purchased and fabricated materials. These controls shall prevent damage, deteriortion, loss or substitution.

2. Identification

Each module or subassembly/assembly shall be identified in a permanent and legible manner with suitable labels or markings as specified in the contractual instrument. The contractor's standard serialization and identification procedures may be utilized to the extent they are in compliance with the contractual instrument.

3. Traceability

Materials, parts, devices, and assemblies shall be identified by unique part numbers to ensure:

a. Functional hardware and major assemblies can be related to fabrication, inspection, test and operating records.

b. That all required buyer requirements and options are satisfied to produce hardware as ordered.

c. Future repair parts and production reorders will be interchangeable (directly or as a replacement).

d. Support of failure reporting/analysis procedures and prevention of recurrence of defects.

e. Ability to locate suspect hardware in systems or subsystems already processed or delivered.

f. That all parts and hardware listed in parts catalogs, illustrated parts breakdown documents, etc., provided to the customer, are identifiable.

Further detail identification methods (e.g., serial numbers, log numbers, heat numbers or date codes) shall be selected depending on the nature of the hardware and its criticality to safe, reliable and economical energy system operation. Serial numbers shall be applied to major functional replacement hardware and to that hardware which the energy system specifies for reasons of maintenance during operations.

F. RECEIVING INSPECTION

The contractor should maintain a receiving inspection system which ensures that all items are covered by warranty and/or:

1. That nonconforming materials, parts or subassemblies shall not be used in the fabrication or assembly of any subsystem/system.

2. That records are maintained of all inspections.

3. That procured articles and materials indicate evidence of inspections and tests performed by the suppliers in accordance with purchase requirements and are accompanied with required inspection and test data.

19

4. That supplier inspection and test data are acceptable by conducting inspections and tests of selected characteristics. As a minimum, receiving inspection and test shall include verification of characteristics and design criteria which have not been source-inspected by the contractor and which can be verified without disassembly of the article. Particular emphasis shall be placed on those characteristics for which nonconformances may not be detected during subsequent inspection and test. Inspections and tests shall be acccomplished in accordance with established inspection and test procedures.

5. That periodic disassembly is accomplished as appropriate for more detailed verification of the specified requirements.

6. That identification and data retrieval requirements have been met and are maintained; that all required data and records are complete and correct, and that articles and materials can be directly related to applicable supplier records.

7. That the quality status of articles and materials is maintained during receiving inspection and test operations. This shall include physical separation and identification of articles and materials according to the following categories:

   a. Items awaiting inspection or test results,

   b. Conforming items, and

   c. Nonconforming items.

8. That articles and materials and their records clearly indicate their acceptance or nonconformance status when released from receiving inspection and test.

G. INSPECTION AND TEST

The contractor shall maintain an effective inspection and test system which shall include provisions for defining and verifying article and material control of all processing and manufacturing operations, and to verify that production hardware satisfies his own requirements as well as applicable regulations, codes, standards, specifications and contractual requirements. Inspection and test could be limited to verifying warranteed performance. This is at the discretion of the cognizant Field Center.

1. In-process Inspection and Test

   The contractor should provide the necessary planning functions for the accomplishment of in-process inspections and tests and an adequate documentation system which substantiates their accomplishment. The documentation should provide for:

   a. Orderly and timely inspection and testing at the earliest opportunity and through all phases.

b. Coordination and sequencing of inspection and testing conducted at successive levels of assembly to ensure satisfactory articles and materials and to minimize unnecessary testing.

c. Economical and effective use of equipment, facilities and personnel.

d. Availability of calibrated inspection and test equipment.

e. Ensuring that any unsatisfactory conditions are discovered and documented and that remedial and preventive actions are taken at the earliest possible time.

2. End Item/Final Preshipment Inspection

The contractor shall perform final preshipment tests and inspections under conditions that will simulate end use without damage to the end items, and will provide a valid measurement of overall quality. After final test and inspection of the end item, any modification, repair, disassembly, or careless handling by the supplier that may jeopardize the quality, should void all previous inspections and would be cause of reinspection and retest. The extent of reinspection and retest is a Field Center decision.

3. Shipping Inspection

The contractor should verify that:

a. All operations authorized and required to be performed at the plant or test site have been satisfactorily completed.

b. Accompanying documents have been properly identified as to inspection status by appropriate contractor's stamps.

c. All articles, equipment, materials and accompanying documentation have been preserved and packaged in accordance with applicable procedures and requirements.

d. All articles and materials have been identified and marked in accordance with applicable procedures and specifications.

e. Handling devices and transportation vehicles are suitable for the articles and materials involved so as to prevent damage.

f. The loading and transportation methods conform to applicable and requirements.

H. MATERIAL REVIEW BOARD (MRB)

The contractor normally provides for the review, control and disposition of all nonconforming material. Each nonconformance must be reviewed, a disposition made by contractor personnel vested with this responsibility, and positive corrective action taken to prevent recurrence of similar nonconformities. The Material Review Board (MRB) shall be comprised of one representative whose primary responsibility is quality and one member whose

primary responsibility is engineering. The identity of each member of the MRB and the area of his responsibility shall be made known to the procuring agency. The Field Center maintains the final authority or approval or disapproval on all MRB actions by the contractor.

I. CORRECTIVE ACTION

Corrective action involves both remedial and preventive actions.

Conditions adverse to quality (nonconformance, problems and unsatisfactory conditions) should be identified promptly, corrected, and action taken to prevent recurrence.

1. Safety-Related Hardware

Nonconformances involving defects affecting safe operation and/or use of safety-related hardware must receive priority attention in determining their basic causes and in developing effective preventive action.

2. Closeout of Nonconformances

Nonconformances should be considered open until remedial and preventive actions have been completed and verified by reinspection or retest. If the corrective action involves a change to documents, it must remain open until the pertinent, documents have been modified as required.

22

SECTION V

PRESERVATION, PACKAGING AND SHIPPING

A. PACKAGING

The contractor should provide for the protection of the quality of the product to prevent deterioration, corrosion, damage and contamination. Packaging procedures should be utilized and provide for protection during storage and transportation to destination.

B. SHIPPING

The contractor must control all articles and materials shipped from his plant to ensure that:

1. Preservation and packaging is in accordance with applicable procedures and requirements.

2. All items have been identified.

3. Handling devices and transportation vehicles are suitable for materials involved so as to prevent damage.

4. The loading and transportation methods conform to applicable specifications and requirements.

C. DOCUMENTATION PACKAGE

The contractor should include a complete documentation package with his shipment.

23

SECTION VI

FIELD INSTALLATION AND CHECKOUT

The contractor should prepare and utilize all assembly, inspection and test procedures for field site erection and checkout. It should include the following:

A. RECEIVING INSPECTION

Receiving inspection will provide assurance that all equipment is in good condition and has sustained no damage during shipment and that all necessary documentation is included.

B. IN-PROCESS INSPECTION

The contractor should have established inspection and test procedures for the control of all assembly operations. The Field Center should reserve the right to inspect hardware as deemed necessary.

C. FINAL INSPECTION/TEST

Final inspection and test procedures should include:

1. Nomenclature and identification of the article or material.

2 Characteristics and design criteria to be inspected or tested including values for acceptance and rejection

3. Hazardous situations or operations.

4 Conditions to be maintained.

APPENDIX A
JPL QUALITY ASSURANCE WORKMANSHIP STANDARDS

QAWS 100-SERIES	TITLE
100.00	Requirements
100.10	Soldering
100.20	Component Installation
100.30	Bonding
100.40	Fabrication of Printed Wiring and Terminal Boards
100.50	Assembly and Subassembly Wiring
100.60	Potting of Connectors
100.70	Basic Cabinets
100.80	Solderless Connections *(Wire Wrap)
100.81	Solderless Connections *(Termi-Point)
100.90	Cabinet/Panel Assemblies

QAWS 200-SERIES	
200.00	Shield Terminations
200.10	Mechanical Assemblies (Basic)
200.40	Identification & Marking (General)
200.41	Anodic Coatings for Aluminum and Aluminum Alloys
200.42	Chemical Film Coatings for Aluminum and Aluminum Alloys
200.43	Painted Surfaces (General)
200.50	Mechanical Engraving
200.70	Brazing of Steels, Copper, Copper and Aluminum Alloys
200.80	Machined Components
200.90	Castings

QAWS 300-SERIES	
300.00	Forgings - Steel and Aluminum

QAWS 2000-SERIES	
2000.10	Welds - General
2000.40	Power Wiring, Conduit Installation and Related Electrical Equipment

QAWS 3000-SERIES	TITLE
3000.00	Major Structural Assemblies
3000.10	Welds - General
3000.20	Painted Surfaces for Structural and Panel Assemblies
3000.30	Bolting of Structural Joints
3000.40	Riveting - Solid Aluminum
3000.50	Hydraulic Components and Fluid Lines
3000.60	Welds - Structural

APPENDIX B

QUALITY GUIDELINE CHECKLIST

A. INTRODUCTION

The Quality Guideline Checklist provides a listing of suggested Quality activities for three project phases: Design, Procurement/Construction/Fabrication/Installation and Operation/Maintenance/Test. This checklist is intended to be used by the contractor as a guide for determining quality activities to be addressed in the Quality Assurance Program Plan.

B. DESIGN

1. Design Review and Design Review Support

   a. Establish a list of engineering-identified items that are critical to the project and provide for the establishment of quality requirements necessary for their control.

   b. Provide review of drawings, specifications, procedures, instruction and changes to insure producibility and testability of design. Verify document adequacy for use in planning quality program activities.

   c. Review design documentation for compliance with applicable standards.

   d. Review specifications, standards and drawings to insure that they provide a complete baseline for quality control of procurement, construction, fabrication, installation, test, operation and maintenance.

2. Quality Inputs to Technical Documentation

   a. Provide for inclusion of quality requirements, i.e., quality assurance provisions material and process certification requirements, in the specifications.

   b. Provide for recommendation of additional standards and requirements for inclusion in technical documentation as needed to implement the quality program.

3. Long-Lead Procurement Control

   a. Provide for the qualification and maintenance of qualification status of suppliers quality control system and operations.

   b. Provide for the transmission of all technical and quality requirements to suppliers.

   c. Provide authorization for contractors vs. quality organization to disapprove the use of suppliers who do not have an adequate quality system to meet procurement requirements.

4. Subcontract Support

   a. Provide for the review of subcontract documentation and inclusion of quality assurance requirements.

   b. Provide for review and certification of inspection and test laboratories for use in support of design activities.

   c. Insure that specifications of manufacturer's warranties are required, where practical, in subcontracts.

5. Quality Audits

   a. Provide for planned periodic audits of contractors and subcontractors and to assure compliance with all quality requirements.

   b. Provide for planned periodic audits of configuration management system including audits of documentation baseline, control of technical documentation approval, release and engineering change cycle and documentation storage and distribution

C. PROCUREMENT, CONSTRUCTION, FABRICATION AND INSTALLATION

1. Quality Documentation

   a. Provide for the establishment and maintenance of written procedures defining the quality program.

   b. Require the establishment and maintenance of a "quality manual" that will serve as a primary document for all quality manuals, procedures, etc. Documentation distributed throughout the contractor's organization must be directly traceable to the quality manual.

2. Procurement Control

   a. Provide for the qualification and maintenance of qualification status of supplier's quality control system and operations.

   b. Provide authorization for contractor's quality organization to disapprove the use of suppliers who do not have a quality system adequate to meet procurement requirements.

   c. Provide for the transmission of all technical and quality requirements to suppliers.

   d. Provide for evaluation of procured articles against order requirements.

   e. Provide a system to assure and record action to correct and prevent recurrence of discrepancies in purchased items.

37

f. Receiving Inspection

1) Provide for written instructions identifying inspections, and tests, sampling plans and acceptance criteria of all purchased material.

2) Provide for and maintain a file of objective evidence to show that all materials and articles received by the contractor for incorporation into project end item meet order requirements.

3) Maintain records of tests, inspections and certifications of purchased supplies.

4) Provide a method for identification and segregation of nonconforming materials to prevent their use.

g. Storage, Handling, Shipment

1) Provide for control of quality during storage and shipment to prevent damage or deterioration. Specify methods, materials, documentation and special requirements for handling, storing, preserving, marking and shipment.

2) Provide for environmental protection of material and equipment after receipt, during storage, and prior to actual use in construction.

3) Provide for the control of shelf-life-limited materials and the rejection of materials that exceed their shelf life.

3. Fabrication Control

a. Provide for the establishment of fabrication process controls governing the application of the process, preparation of articles or materials, methods for verifying adequacy and records for routine controls to insure uniform quality of fabrication processes such as welding, plating, heat treating, and painting.

b. Provide for control of fabrication operations through detailed work instructions specifying critical characteristics and tolerances, special precautions, tooling and fixture requirements to control work operations such as machining, and assembling to ensure specified characteristics are maintained. Includes certification of personnel and equipment, and the maintenance of records to verify conformance.

c. Provide workmanship standards for use in the contractor's fabrication and quality programs.

d. Tool Control

1) Provide for inspection at set intervals to verify accuracy of production jigs, fixtures, templates and patterns that are used for inspection.

2) Verify tooling prior to use and provide periodic inspections and maintain records to verify continued accuracy during use.

3) Provide a system which will provide records for accountability, identification and maintenance of tooling.

4. Measuring and Test Equipment

a. Provide for inspection measuring and test equipment maintenance and calibration prior to initial use and at scheduled intervals. Provide for the establishment of records and controls to insure maintenance and calibration are performed as scheduled and out-of-calibration equipment is not used.

b. Provide for establishment of review procedures to adjust frequency of maintenance and calibration as required to maintain required accuracies.

c. Provide for calibration of all test and measuring equipment using a standard directly traceble to the National Bureau of Standards or a secondary standard acceptable to the DOE project manager.

d. Provide for record maintenance of measurement standards and equipment calibration. Record shall include identification of equipment to be calibrated, identification of calibration procedures, calibration intervals, dates and results of each calibration, due date of next calibration, name of individual performing calibration, and calibration facility.

e. Provide for establishment of a unique method for identifying and marking or tagging measurement standards and equipment to indicate calibration status and due date of next calibration.

5. Quality Drawing and Change Control

a. Provide for the review of engineering changes to determine the effect on quality program, and to assure that inspection/test procedures and quality documentation reflect latest engineering changes.

b. Provide for a document control system to assure that procedures and technical documentation used for inspection and test reflect the latest applicable changes.

6. Inspection and Test

a. Provide for an Inspection and Test Program Plan and Schedule to ensure compliance with contract requirements, i.e., drawings, specifications, standards, quality requirements.

b. Provide for a system to classify the characteristics of contractor and subcontractor materials and equipment and establish criticality of inspection and test points. Consider effect on safety, reliability, cost, effect of failure, quality history, and feasibility of additional tests at later stage of fabrication or

assembly. Include requirements for sampling plans, witnessing vendor tests, special surveillance, etc., from classification system.

c. Provide for inspection and test planning to identify:

1) Inspection and test points in the procurement, construction, fabrication and installation work flow

2) Characteristics to be inspected, referenced to detail inspection and test procedures
3) Sampling plans
4) Mandatory hold points
5) Inspections and tests to be witnessed by customer
6) Data requirements

7. Material Identification and Status

a. Provide for the identification of the inspection and test status of materials, processes and equipment through all stages of manufacturing, storage, construction, fabrication and installation.

8. Nonconforming Material

a. Provide for and maintain a system for controling nonconforming material. Include procedures for identification, marking, segregation and disposition of all nonconforming material.

b. Provide for issuance of documents for each nonconformance containing as a minimum:

1) Identification of nonconforming material and serial number
2) Description of nonconformance
3) Actual requirement and tolerance
4) Disposition - scrap, rework, repair
5) Method of rework/repair
6) Reinspection/retest results
7) Dates and signatures of authorized personnel
8) Assignment of responsibility and identification of need for corrective action to prevent recurrence

c. Provide for establishment and maintenance of all nonconformance records and to report nonconformance trends, analyze causes, and initiate corrective action.

9. Corrective Action

a. Provide for a corrective action system to detect and correct quality defects. The corrective action system shall include the contractor's operations, those of his suppliers, any user-reported deficiencies, and shall follow the following sequence:

1) Notification of function responsible for deficiency
2) Determination of extent and cause of deficiency

30

3) Establishment of preventive actions
4) Rework of other existing products in all stages of completion
5) Follow-up to assure corrective action and review of corrective action effectiveness

10. Quality Records

a. Provide and maintain records to objectively document quality program activities. Records include: audit reports, calibration records, customer surveys, corrective action reports, etc.

b. Provide and maintain records of all incoming, in-process and final inspection and test data. Records shall indicate, as a minimum, item identification, actual measurement or test results, amount inspected or tested, amount accepted and amount rejected, number and type of deficiencies, lot size, disposition, and date.

11. Warranties

a. Insure that specifications of manufacturing warranties are required, where practical, in Request for Proposals (RFP), procurement and subcontractor documentation.

b. Provide for review of warranties in bids and proposals for adequacy and completeness.

c. Provide for monitoring of warranteed items and initiation of warranty claims.

12. Quality Audits

a. Provide detailed audit checklists and an audit reporting and corrective action system.

b. Provide for planned periodic audits of the contractor and his subcontractors and vendors to assure compliance with all quality program requirements.

c. Provide for planned periodic audits of configuration management system including audits of control or technical documentation approval, release and engineering change cycle and documentation storage and distribution.

D. OPERATION MAINTENANCE AND TEST

1. Quality Documentation

a. Provide for the establishment and maintenance of written procedures defining the quality program for control of operational maintenance and test.

2. Procurement Control

a. Provide for the transmission of all technical and quality requirements to suppliers.

b. Provide for evaluation of procured articles against order requirements.

c. Provide a system to assure and record action to correct and prevent recurrence of discrepancies in purchased items.

d. Receiving Inspection

1) Provide for written instructions identifying inspections, tests and acceptance criteria of all purchased material.

2) Provide for and maintain a file of objective evidence to show that all spares received by the contractor meet order requirements.

3) Maintain records of tests, inspections and certifications of purchased spares.

e. Storage, Handling, Shipment

1) Provide for control of quality during storage and shipment to prevent damage or deterioration. Specify methods, materials, documentation and special requirements for handling, storing, preserving, marking and shipment.

2) Provide for environmental protection of spares material and equipment after receipt, during storage, and prior to actual use in operation and maintenance.

3. Measuring and Test Equipment

a. Provide for inspection measuring and test equipment maintenance and calibration prior to initial use and at scheduled intervals. Provide for the establishment of records and controls to insure maintenance and calibration are performed as scheduled and out-of-calibration equipment is not used.

b. Provide for establishment of review procedures to adjust frequency of maintenance and calibration as required to maintain required accuracies.

c. Provide for calibration of all test and measuring equipment using a standard directly traceable to the National Bureau of Standards or a secondary standard acceptable to the DOE project manager.

d. Provide for record maintenance of measurement standards and equipment calibration. Records shall include identification of equipment to be calibrated, identification of calibration procedures, calibration intervals, dates and results of each calibration, due date of next calibration, name of individual performing calibration, and calibration facility.

e. Provide for establishment of a unique method for identifying and marking or tagging measurement standards and equipment to indicate calibration status and due date of next calibration.

4. Quality Drawing and Change Control

   a. Provide for the review of engineering changes to determine effect on quality program and assure inspection/test procedures and quality documentation reflect latest engineering changes.

   b. Provide for a document control system to assure procedures and technical documentation used for inspection and test reflect latest applicable changes.

5. Inspection and Test

   a. Provide for an Inspection and Test Program Plan to ensure compliance with contract requirements for operation, maintenance and test.

   b. Provide for inspection and test planning to identify:

      1) Inspection and test points in the test and maintenance operation
      2) Characteristics to be inspected, referenced to detailed inspection and test procedures
      3) Mandatory hold points
      4) Inspection and tests to be witnessed by customer
      5) Data requirements

6. Material Identification and Status

   a. Provide for the identification of the inspection and test status of all spares through operation, maintenance and test.

7. Nonconforming Material

   a. Maintain a system for controlling nonconforming material. Include procedures for identification, marking, segregation, and disposition of nonconforming material.

   b. Provide for issuance of documents for each nonconformance containing as a minimum:

      1) Identification of nonconforming material and serial number
      2) Description of nonconformance
      3) Actual requirements and tolerance
      4) Disposition - scrap, rework, repair
      5) Method of rework/repair
      6) Reinspection/retest results
      7) Dates and signatures of authorized personnel
      8) Assignment of responsibility and identification of need for corrective action to prevent recurrence

   c. Maintain all nonconformance records and report nonconformance trends, analyze causes and initiate corrective action.

8. Corrective Action

   a. Maintain a corrective action system to detect and correct quality defects. The corrective action system shall include the contractor's operations, those of his suppliers, and user reported deficiencies and shall follow the following sequence:

      1) Notification of function responsible for deficiency
      2) Determination of extent and cause of deficiency
      3) Establishment of preventive actions
      4) Rework of other existing products in all stages of completion
      5) Follow-up to assure corrective action and review of corrective action effectiveness.

9. Quality Records

   a. Provide and maintain records to objectively document quality program activities.

   b. Provide and maintain records of all incoming, in-process and final inspection and test data. Records shall indicate, as a minimum, item identification, actual measurement or test results, amount inspected or tested, amount accepted and amount rejected, number and type of deficiencies, lot size, disposition, and date.

10. Warranties

   a. Provide for monitoring warranteed items and initiation of warranty claims.

11. Audits

   a. Provide for planned periodic audits of the contractor and vendors to assure compliance with all quality program requirements.

   b. Provide detailed audit checklists and audit reporting and corrective action.